RAW MATERIALS

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CONCENTRATION OF MINERAL ADMIXTURES IN THE FINE FRACTION OF QUARTZ POWDER DURING MILLING

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A qualitative picture of the enrichment of the fine fraction of quartz sand during the milling process is obtained experimentally using a natural impurity (albite). It is shown that the glass made from the fine sand fraction is optically and structurally inferior to that made from the course fraction.

Key words: quartz glass, quality, natural quartz, milling, admixtures.

The unique properties of quartz glass and its areas of application and quantities used as well as the quartz-glass quality required in modern science-intensive industries are well known.

Today, the highest-quality glass is made from synthetic silicon-dioxide powder. Its high cost is due to the great complexity of the technology used to synthesize the initial powered quartz material, the high cost of the technological equipment, and the one-time tooling for melting such glasses. At the same time, quartz glasses obtained from natural quartz from which mineral and gas-liquid inclusions have been removed can be used in number of modern technologies.

Ordinarily, quartz powders with fractions from + 0.1 to – 0.4 mm are used for making quartz glass. For this reason comminution and milling of the initial quartz material to this particle-size range is incorporated in the enrichment technology. The process unavoidably occurs together with mineral inclusions which are present in natural quartz. A quite complete list of such minerals is presented in [1]. The quartz is harder than most mineral inclusions [2]. For this reason, the inclusions are more effectively comminuted during milling, including with the participation of the quartz, and become concentrated in the fine fraction of the quartz powder during sizing. We have made an experimental assessment of the contamination of quartz-powder fractions which occurs when the quartz is milled.

Pure quartz with no mineral inclusions was milled together with albite of the same quality. The mass content of the quartz was 90% and that of albite 10%. The hardness of albite on the Mohs scale is 6 and that of quartz 7. Albite crystals possess twinning and cleavage planes, and these crystals are easily milled. The comminution and milling were performed in a mortar and pestle both made of the same quartz glass. The powder obtained was sized using sieves into the fractions – 0.1, – 0.2, – 0.3, – 0.4, – 0.5, and – 0.63 mm. X-ray phase analysis was used to make a qualitative assessment of the relative content of albite in all powder types.

The x-ray studies were performed at the Institutes of Mineralogy and Metal Physics at the Ural Branch of the Russian Academy of Sciences. Figure 1 displays the change of the albite content in all powder fractions. The experiments attest that even the quite strong mineral albite enriches the fine powder fraction during the comminution and milling process. Evidently, in this manner, other softer mineral inclusions also become concentrated in the fine fraction of the quartz powders, thereby lowering the purity of the raw material.

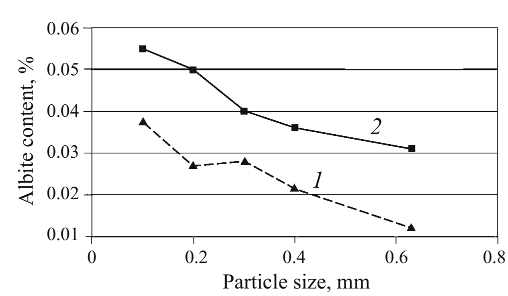

Fig. 1. Variation of the albite content in quartz powder with different particle sizes when the fractions are milled together, as indicated by data obtained at the Institute of Mineralogy (*1*) and the Institute of Metal Physics (*2*).

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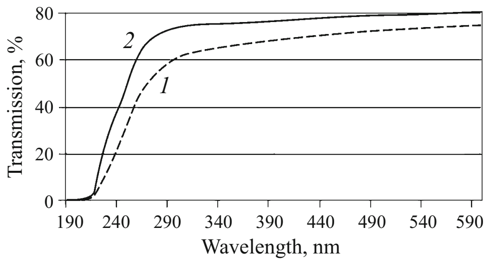

Fig. 2. Transmission spectra of glasses made from fine quartz sand — 0.1 mm fraction (*1*) and coarse quartz sand — from + 0.35 to – 0.40 mm fraction (*2*).

We shall now examine the effect of the segregation of mineral inclusions in the fine fraction of quartz powders on the quality of the quartz glass.

Quartz powder obtained from crushed quartz rock from the Berkutinskoe vein in the Kyshtymskoe deposit was prepared using one of the technologies at the Institute of Mineralogy of the Ural Branch of the Russian Academy of Sciences and sized into two fractions: – 0.1 and from + 0.35 to – 0.40 mm. Quartz glass was made from each powder fraction using the method described in [3], and samples for investigation of optical characteristics were prepared [2]. Figure 2 displays the transmission spectra of the glasses recorded in the wavelength range 190 – 600 nm using an SF-56 computerized optical spectrophotometer. The spectra show that the visible-range optical transparency of the glass made from the coarser fraction is higher than that of the glass made from the fine fraction.

The improvement in the quality of quartz glass as a function of the particle-size composition of quartz sand is also seen in the shadow photographs of the samples (Fig. 3). The enlarged images of the samples and their defects were obtained using an optical setup with an 8-m baseline. The depth of focus, i.e., the thickness of the region projected onto the screen, was 8 mm. The black dots and circles in the photographs are air bubbles in the glass, and the white formations are striae [4] in the interior of the glass. The number of defects in the glasses is correlated with the particle sizes of the initial quartz powder.

Substantially more air bubbles and striae are seen in Fig. 3*a*. This also indicates contamination by mineral inclusions of the fine fraction of the quartz powder during milling of the comminuted quartz rock. Apparently, the air bubbles in this glass block are formed primarily as a result of the decomposition of biotite, muscovite, and other mineral inclusions, which are present in substantial quantities in the quartz from the Berkutinskoe vein, and not only as a result of the opening of gas-liquid inclusions. It is known that as the quartz powder is ground the content of the gas-liquid inclusions decreases as a result of their mechanical opening [5], which should decrease the number of bubbles in the glass block. However, the observed picture is different and supports our supposition.

It was established that on comminution and milling the fine fraction of the granulated quartz from the Berkutinskoe vein becomes contaminated with the mineral impurities of natural inclusions.

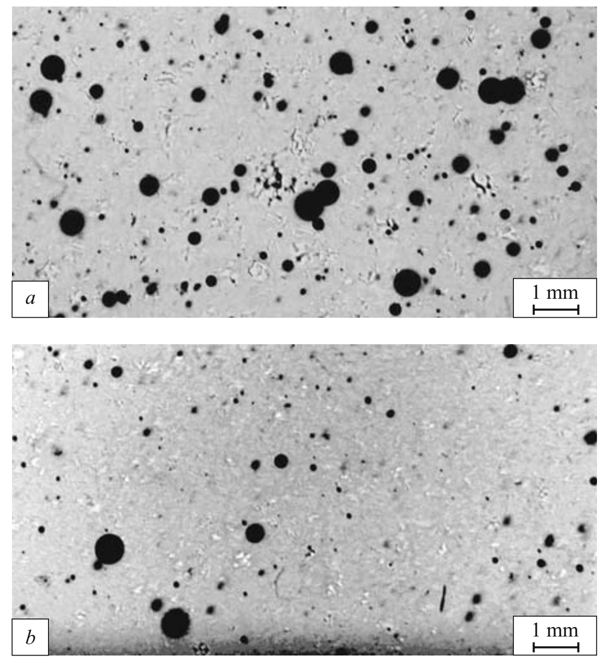

Fig. 3. Dark images of the quartz glasses founded from quartz sand with fine 0.1 mm (*a*) and coarse from + 0.35 to – 0.40 mm (*b*) particle-size fractions.

The effect observed shows that to make high-quality quartz glass the purified quartz sand must also be sized and its coarser fraction used. Since vein quartz is subject to similar physical, chemical, and mechanical effects during natural metamorphism, such recommendations can probably be made for most quartz deposits.

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